

Background material for presentation on Lower Trophic Process Work

How does process work contribute to understanding fisheries recruitment dynamics and ecosystem functioning? The RPA ([FOCI](#), [EMA](#), [RECA](#), [REEM](#)) conducts research in all of Alaska's LMEs to provide the mechanistic rationale to explain correlations between climate data and fisheries abundance trends. Understanding is provided to managers and stakeholders for use in the development of their assessments and recommendations.

The RPA focuses on processes influencing growth and mortality during the first year of life, as these vulnerable life stages have been shown to determine recruitment strength ([Duffy-Anderson et al. 2015](#)). We conduct seasonal ecosystem [surveys](#) (March-October), sampling across trophic levels. Surveys are designed for two purposes: 1) to provide the data that support the long time series that are used to evaluate current observations in light of historical patterns, and 2) to provide a platform for directed work to reveal underlying forcing variables, linkages, and processes. Mechanistic understanding is advanced most often when long-term observations are coupled with processes-directed research.

Examples of how process work at lower trophic levels has advanced understanding of fisheries recruitment dynamics:

Nutrients – Phytoplankton – Walleye Pollock Production

Sequential Cold Years over the EBS shelf have been correlated with above-average recruitment for walleye pollock. However in 2007, a Cold Year in the middle of a spate of Cold Years (2006-2012), the observed correlation between temperature and pollock recruitment became decoupled and pollock recruitment was lower than anticipated. Process-based examination of ocean conditions and trophic linkages during 2007 revealed a sequence of events that precipitated the lower recruitment. Weak wind-mediated mixing prompted strong stratification over the SE Bering Sea shelf in spring. The subsequent emergence of a two-layered system minimized the mixing of nutrients, in particular silicate, from depth to the near-surface layers. Diatom production is limited by N and Si, and it was noted that chl_a production over the shelf was lower than average (spring bloom). Copepods have limited ability to feed on small-celled algae, and it is hypothesized that the poor algal lipid production propagated to the zooplankton community that forms the prey base of young walleye pollock. Poor feeding conditions for pollock in turn led to reduced fitness, higher mortality among age-0s and lower overall recruitment.

[Eisner et al. 2012](#), [Heintz et al. 2013](#), [Eisner et al. 2015](#), [Gann et al. 2015](#), [Sigler et al. 2016](#)

Chlorophyll – Sablefish

Positive relationships between chl_a production, onshore transport, and warmer temperature and age-2 sablefish recruitment (eastern Gulf of Alaska) have been demonstrated for sablefish. Process-based work is in development now to identify whether the mechanism underlying the relationship is similar to that described for pollock in the Bering Sea (above).

[Sigler and Zenger 1989](#), [Sigler et al 2001](#), [Yasumiishi 2015](#)

Crustacean Zooplankton – Walleye Pollock

Sequential Cold Years over the EBS shelf have been correlated with above-average recruitment for walleye pollock; poor recruitment has been shown to follow sequential Warm Years. The relationship between zooplankton production and fish production has been investigated further through a series of process studies linking climate-mediated differences in zooplankton community structure, fish and prey energy content, and shifts in spatial distribution. Analyses of zooplankton composition revealed that during Warm Years, the zooplankton community shifted in composition toward smaller-sized zooplankton taxa with reduced lipid content. In Cold Years, the zooplankton community was comprised taxa with larger body sizes and higher lipid content. Condition analyses of zooplanktivorous age-0 walleye pollock indicate that energy content of fish is also reduced during warm years as individuals feed on low energy prey, and distributional analyses indicate that spatial overlap of prey and predator is important to survival. It is hypothesized that age-0 pollock require sufficient provisioning on spatially available, lipid rich zooplankton through the first summer and autumn to be survive the overwinter period.

Heintz et al. 2013, [Eisner et al. 2014](#), [Siddon et al. 2015](#)

Gelatinous Zooplankton

Changes in abundance of gelatinous macrozooplankton (jellyfish) have been correlated with broad-scale shifts in Bering Sea oceanographic conditions. Jellyfish are voracious zooplanktivores and also routinely co-occur with zooplanktivorous forage fishes (pollock, capelin, herring. Presently a study is underway to examine whether jellyfish compete with forage fish for zooplankton prey. Factors being examined are temporal and spatial overlap, dietary overlap, and digestion rates. Products will include development of competition metric that will forecast shifts in forage fish abundance with jellyfish biomass.

Ichthyoplankton

The FOCI Program has long time series data of larval fish collections from both the Gulf of Alaska and Bering Sea (1980s). Marine fish larvae are part of the lower trophic community they respond rapidly to ecosystem shifts, so indices developed from ichthyoplankton time series have significant potential to be early harbingers of future ecosystem changes. Community analyses of larval fish time series data from the Gulf of Alaska show that there are species groups of larval fish that respond similarly to environmental forcing. In particular, rapid shifts in abundance and distribution of fish larvae are observed in response to El Nino events, oscillations in the PDO, stratification, and flow. Changes manifest more rapidly in the larval fish community than they do in the adult fish community where climate-mediated variability often takes several years to become evident. A new FATE project will integrate larval fish time series data collected at Fishery Science Centers from Baja California to Alaska (SWFSC CalCOFI, and NWFSC Newport, OR) to develop integrated biodiversity indices and single species metrics that will be used to evaluate change over time and inform EBFM.

[Boeing and Duffy-Anderson 2008](#), [McClatchie et al. 2014](#), [Guy et al. 2014](#), [Matarese et al 2015](#)

Forage Fishes

Forage fishes that serve as prey to economically and ecologically important piscivorous groundfishes have been systematically collected from the Bering Sea and Gulf of Alaska since the 1990s and early 2000s. Previous work has shown that forage fish abundance varies in response to varying biological and physical oceanographic conditions. In 2014 and 2015, anomalous warm-water ocean conditions were observed from California to Alaska, "The Blob." During this period declines in forage fish catch were documented (age-1 pollock, age-2 pollock, capelin, eulachon), suggesting a link between production of forage fish prey base and feeding and energy transfer to upper trophic levels. Coincident with changes observed in forage fishes, pronounced changes were also being observed at other trophic levels. In particular, various news agencies reported on an extraordinarily large die off of common murrelets in Prince William Sound. Ornithologists noted that birds appeared emaciated and suspect declines in forage fish availability underlie observations. A new successfully funded project, written in collaboration with University of Alaska faculty, USGS scientists and USFWS researchers will test this hypothesis, examine mechanisms, and produce an index of vulnerability for seabird populations across several species.

[Wilson et al. 2015](#)

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Strategies to obtain/manage data - in house relational databases, strive for 1-year turnaround (chla, plankton, otoliths, diets, catch, size, composition, on-board indices of plankton, diets), PARR, public sites (NODC, IIS, AOOS, NCEAS, NPRB, COPEPOD), public dissemination through media outlets

Inclusion into management - Ecosystems Considerations chapter, Species-specific report cards, presentations at SCC and Council meetings

Peer-review - special volumes, CIE Review 2015, discussions with AFSC Leadership, Leads for RPA

Communication - special symposia, AFSC Hot Topics, Twitter, radio, & print interviews, presentations in local communities, science days outreach